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Predictors of wound infection in hip and knee joint replacement: results from a 20 year surveillance program

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Abstract

Background. Deep wound infection (DWI) in total knee (TKA) and total hip (THA) arthroplasty has been shown to highly correlate with superficial surgical site infection (SSSI). Although several studies have reported hospital factors that predispose to SSSI, patient factors have not been clearly elucidated.

Methods. All patients undergoing TKA ($n = 1181$) and THA ($n = 1124$) surgery during the period 1977–1995 at our institution were observed at the end of a 30-day post-operative period. Thirty-three patients that developed SSSI during this period constituted the study group. The control group was composed of 64 matched subjects that did not develop SSSI. A chart review was applied to abstract DWI cases during the first 18 post-operative months for the study group and for an average of 6.7 years for the control group (range 5–18.2 years). Potential risk factors for SSSI were used as predictors of SSSI in a logistic regression analysis.

Results. During the 18-month observation period 19 out of the 33 study subjects (58%) developed DWI. No DWI was registered in the control group (the difference was significant, $p < 0.0001$). Of the nine pre-operative, five intra-operative, and five post-operative factors examined, only hematoma formation (odds ratio = 11.8; $p = 0.001$) and days of post-operative drainage (odds ratio = 1.32; $p = 0.01$) were significant predictors of SSSI. The cases consumed more health care resources at all stages of the medical process.

Conclusions. Our results (1) confirm the strong correlation between the probability of developing DWI and SSSI; (2) indicate that hematoma formation and persistent post-operative drainage increase the risk of SSSI. We hypothesize that post-operative monitoring of patients for hematoma and persistent drainage enables earlier intervention that may lower the risk of developing SSSI and subsequent DWI.

Keywords: Arthroplasty; Knee; Hip; Prostheses; Infection; Risk factors

Introduction

Joint replacement surgery has proven to be the most cost-effective procedure for patients with end stage joint disease [6,8,23,29,31,32]. As a result of an aging population and widening indications for arthroplasty surgery, 224,781 primary total knee arthroplasty (TKA) and 232,109 primary total hips arthroplasty (THA) procedures were performed in the United States in 1995 [25]. The increase in the demand for TKA and THA procedures has been propelled by the outstanding long-term results and by recent technological advancements in prosthetic design, instrumentation and surgical technique [17]. The annual rate of joint replacement is expected to continue to increase and to double by the year 2025 [25].

One of the biggest threats to a successful outcome following joint arthroplasty surgery is infection of the prosthesis or deep wound infection (DWI). At all stages of the treatment process, patients with DWI are subjected to a greater risk of local and systemic complications and mortality. The treatment of DWI is associated

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with an increased number and length of hospital admissions at an estimated cost of $44,935 per case [31,32]. As a consequence of high costs and partial reimbursements, some hospitals reject patients requiring treatment for DWI [22].

Hanssen and Rand [13] studied the prevalence of DWI at the Mayo Clinic from 1969 to 1996 and reported a 2% rate of infection in 16,035 primary TKA and 1.3% rate of infection in 23,519 primary THA. By combining these rates of infection with the previously reported data, a conservative estimate of 7500 cases of DWI treated annually in the US (4500 infected TKA and 3000 infected THA) can be obtained. The estimated cost to the healthcare system is more than $340,000,000 per year.

The importance of this problem attracted many researchers to studying factors that predispose patients to DWI. Surgical factors such as sterility, laminar airflow in the operating room, pre-operative use of antibiotics, intra-operative use of antibiotic-impregnated cement and post-operative antibiotic regimens are within the control of the medical team [12,13,16,19]. On the other hand, patient factors that increase risk of DWI include: age, chronic obstructive lung disease [18], insulin use [10,24,27], obesity [34,39], number of previous surgical procedures [3], renal insufficiency [30,37] and systemic illnesses (i.e., alcohol abuse, smoking, and steroid use [36,38]. Some intra-operative factors such as the American society of anesthesiologists (ASA) score > 2 [9,12], excessive intra-operative blood loss [36], National Nosocomial Infection Surveillance System (NNIS) score > 2 [12], duration of procedure [16] were also reported as possible risk factors for DWI. Among the post-operative factors, hematoma [3] days of post-operative drainage [20,27], other sites of infection [1,2,35], post-operative transfusion [33], and anticoagulant use [3] were also reported as possible predictors of DWI.

The low rate of DWI and indolent arthroplasty infections make it difficult to diagnose, treat or study this process on clinical, laboratory or radiological grounds [13]. For example *hematoma*, a risk factor for developing DWI, has been defined in Mosby's Dictionary as a "collection of extravasated blood trapped in the tissues that becomes palpable to the examiner and is often painful to the patient". When does post-operative swelling and pain become a *hematoma*? What radiographic parameters in arthroplasty patients differentiate between osteolysis (bone loss secondary to an inflammatory processes directed against wear debris) and infection (which also causes bone destruction)? Furthermore, factors such as past antibiotics use, inappropriate collection techniques, suboptimal conditions of specimens contribute to low sensitivity and specificity of joint fluid analysis

The most promising results in predicting DWI were found in one retrospective matched case-control study conducted by Berbari et al. [5]. The investigators identified four factors: superficial surgical site infection (SSSI) (odds ratio = 35.9), NNIS score of one (odds ratio = 1.7) or two (odds ratio = 3.9), presence of a malignancy (odds ratio = 3.1) and a prior history of joint arthroplasty (odds ratio = 2.0).

Patients who develop SSSI require more rigorous medical treatment and are at high risk for developing DWI [5]. Successful treatment of established SSSI does not change the fact that they need more frequent visits, resources and education, in the hopes of early detection of DWI. If the common-factor for SSSI and DWI model is correct, then by preventing SSSI one can decrease the morbidity and the costs associated with the treatment of SSSI but does not change the probability of developing DWI. However, if the causal model is correct, then by preventing SSSI one can lower the risk of developing DWI. Therefore preventing SSSI is a win–win situation for the arthroplasty patient: we either can prevent SSSI alone (common-factor model) or prevent SSSI and the possible risk of developing DWI (causal model).

To our knowledge we are not aware of any studies that have examined *manageable* patient factors that impact the risk of developing SSSI in arthroplasty patients. Therefore the goal of the study is to

1. to confirm that there is correlation between SSSI and DWI,
2. to identify the combination of pre-operative and manageable intra- and post-operative factors that predispose subjects to SSSI.

Methods

Practice characteristics

Our institution is a tertiary care, 350-bed facility. A total of 1181 TKA and 1124 THA primary procedures were performed from February 1977 to February 1995 and subjected to the Surgical Site Infection Surveillance Program (hospital-wide quality assurance program). The Surveillance Program included a 30-day post-operative scheduled evaluation of patients undergoing a joint replacement procedure by trained staff. This program achieves high clinic-return rates (greater 95%) as a result of systematic reminders and specifics of the population (veteran patients).

Study patients

While patients were in the hospital, trained nursing personnel identified and reported incisions suspicious for infection to the nurse epidemiologist. The nurse epidemiologist made daily visits to the surgical floor

1. to directly inspect suspicious wounds,
2. to review post-operative wound cultures from the microbiology laboratory,
3. to contact the responsible clinical nurse or surgeon.

The surgical site was described as being infected based on CDC definitions.

Late SSSI (diagnosed after discharge yet during the 30-day post-operative period) were identified either when the patient presented to

the emergency room or during scheduled visits to clinics. Patients and family members were educated regarding signs and symptoms of abnormal incision healing and the necessity to visit or contact the VAMC medical center to report the problem.

Control patients

For every study patient identified, two control subjects were selected from the population that did not develop SSSI during the 30-day post-operative period. The study and control patients shared the following characteristics:

1. same operation, i.e., TKA or THA,
2. same gender (the VA population is predominately male and as a consequence the cases and controls were male subjects).

If more than two subjects satisfied the above criteria, then subjects were selected with the least time interval between the two procedures to better approximate the operative environment. To ensure a sufficient followup period to identify the study endpoint (infection), a five-year minimum follow up was necessary for subjects to be included in the study as a control.

CDC definitions of SSSI

SSSI infection must occur within 30 days after the operative procedure and involves only skin or subcutaneous tissue of the incision and at least one of the following is present [15]:

1. purulent discharge from the superficial incision,
2. positive culture from an aseptically obtained culture or
3. the responsible clinician deemed the wound infected based on clinical judgment,
4. one of the following signs and symptoms of infection: "unusual" pain or tenderness, localized swelling, redness or heat and superficial incision is deliberately opened by the surgeon, unless culture of incision is negative.

The following are not reported as superficial incisional SSSI:

1. stitch abscess and
2. incisional SSSI that extends into the fascial and muscle layers (please see DWI).

If the incision yielded an equivocal finding, the infection control nurse examined the patient on a daily basis until a decision was made.

Surveillance program and data collection

The surveillance program was part of a hospital-wide quality assurance program, designed to detect and treat early (30-day) post-surgical infection. As such, consent for treatment was also considered consent for the surveillance program as well as this study.

Data were collected on a daily basis on weekdays from ward visits, emergency room logs, microbiological laboratory reports, and outpatient medical charts as identified by arthroplasty-clinic nurses. Data was collected on Mondays from the same sources on subjects admitted or seen on an outpatient basis over the weekend. Data were stored in the central database and printed SSSI reports were issued monthly as well as semi-annually. Primary arthroplasty subjects diagnosed with SSSI constituted the study group. Variables collected included subject demographics, daily appearance of the wound classification (erythematous, draining, necrotic, or dehiscence), wound drainage, oral temperature, results of wound cultures, presence of drain, blood work (WBC, Hemoglobin, Albumin, serum sugars, antibiotic use, type of surgical procedure, operative Or time, length of hospital stay and the patient risk factors documented in Table 1.

Potential risk factors for SSSI

Risk factors were documented once diagnosis of SSSI was made or a subject was classified as a control. A standardized data collection instrument was used to extract risk factors for cases and controls from the medical chart. We concentrated on factors that have been shown to be predictive with respect to deep infection (see above). The risk fac-

Table 1
Definition of potential risk factors for surgical site infections

	Risk factors	Definition
Pre-operative factors	Age	D.O.B.: days [18]
	Alcohol abuse	>3 drinks/day [11]
	COPD	Chronic bronchitis or emphyema [21]
	Diabetes	Per national diabetes data group [26]
	Insulin use	
	Obesity	Weight $>20\%$ ideal body weight [14]
	Renal insufficiency	creatinine clearance <30 ml/min [7]
	Smoker	Within 14 days of surgery
	Corticosteroid	Systemic steroid therapy at time of surgery
Intra-operative factors	ASA	Reference $\geqslant 2$
	Excessive blood loss	>700 cc for hip; and >100 cc for knee [33]
	NNIS system (SSSI risk scale 0–3 high risk $\geqslant 2$ points)	As defined by the CDC: [9]; OR time >2 h $=1$ point; ASA $>2=1$ point; contaminated case $=1$ point
	OR day drainage	cc during initial 24 h post-operatively
	OR time	>2 h
Post-operative factors	Anticoagulation	Warfarin/low/unfractionated heparin
	Hematoma	Subcutaneous palpable collection of fluid or mass
	Days of drainage	Wound drainage
	Other sites of infection	Ulcer, urinary, pulmonary etc. infections
	Transfusions	Units of PRBC-autologous or homologous

ASA = American society of anesthesiologists pre-operative assessment score; CDC = centers for disease control; NNIS = national nosocomial infections surveillance. [] = definition reference. Collection of blood in the skin was called "purpurea" and was subdivide on the basis of the size of bleeding in the skin. small pinpoint petechia – characteristics of platelet disorders. Larger subcutaneous collections of blood due to leakage of blood from small arterioles and venules was reported as ecchymosis. However, deeper and palpable collection of fluid was diagnosed as hematoma by the caring clinician and was separated from hemarthrosis which is present in the majority of patients who had total joint replacement. The amount of the collection of fluid varied from one patient to the next and had to be palpable to the examiner and painful to the patient.

tors were divided into three groups: pre-operative, intra-operative, and post-operative (Table 1).

DWI

DWI or prosthetic joint infection was diagnosed if any of the following was present [5,15]:

1. purulence spreading through the fascia,
2. intra-operative cultures/intra-operative specimens yielded micro-organisms,
3. purulence surrounding the prostheses observed at the time of debridement,
4. surgery necessitating removal of the prosthesis,
5. acute inflammation as seen during histopathologic examination,
6. a sinus track communicating with the prostheses.

Follow-up data collection

All controls were followed through scheduled yearly appointments until February 1999 for an average period 6.7 years (3.5–20.2 years). Study subjects were followed through scheduled appointments for 18 months.

Resource consumption

Average number of: in-hospital days, readmissions and procedures performed for subjects and cases were extracted from chart review.

Statistical analysis

Univariate data analysis included frequency analysis and parametric and non-parametric two-tailed tests (Student, Mann–Whitney, and Fisher exact tests). Potential risk factors that might contribute to SSSI were categorized as pre-operative, intra-operative, and post-operative and used as blocks in a multivariate logistic regression (see Table 2). Univariate logistic regressions for individual predictor variables, uncorrected for multiple comparisons, are also included for descriptive purposes in Table 2(a) and (b). Data were analyzed using SPSS 8.0 and Statistica'99.

Results

Pre-operative characteristics

The study group was composed of 33 subjects that developed SSSI during the 30-day post-operative period. Of the 66 subjects identified as controls, one was lost to follow up and the other died of unrelated causes (renal failure and coronary artery disease) leaving 64 controls. Risk factors for cases and matched controls are shown for TKA in Fig. 1 and THA in Fig. 2.

Antimicrobial prophylaxis was administered pre-operatively to all of the case subjects: 32 (97%) received Cephazolin, and one received (3%) Vancomycin. Of the

Table 2
Univariate and multivariate analysis of pre-, intra- and post-operative risk factors for surgical site infections in hip and knee arthroplasty subjects treated at the VAMC 1977–1995

	Cases ($n = 33$)	Controls ($n = 64$)	Univariate OR (95% CI)	Multivariate OR (95% CI)
Pre-operative factors				
Age (mean ± S.D.)	65.6 ± 9.1	67.8 ± 9.5	0.97 (0.93–1.01)	
Alcohol abuse	7 (21%)	11 (17%)	1.30 (0.45–3.74)	
COPD	3 (9%)	10 (16%)	0.54 (0.14–2.11)	
Diabetes	7 (21%)	8 (13%)	1.89 (0.62–5.75)	
Insulin use	5 (15%)	3 (5%)	3.63 (0.81–16.27)	
Obesity	20 (61%)	36 (56%)	1.20 (0.51–2.81)	
Renal insufficiency	1 (3%)	1 (2%)	1.97 (0.12–32.51)	
Smoker	10 (30%)	12 (19%)	1.88 (0.71–4.98)	
Corticosteroid use	1 (3%)	4 (6%)	0.47 (0.05–4.37)	
Intra-operative factors				
ASA > 2	20 (61%)	35 (55%)	1.24 (0.52–2.98)	
Excessive blood loss	13 (39%)	28 (44%)	0.84 (0.36–1.97)	
NNIS = 0	1 (3%)	8 (13%)	0 and 1 versus 2 and 3	
NNIS = 1	16 (49%)	21 (33%)	1.06 (0.55–2.05)	
NNIS = 2	14 (42%)	32 (50%)		
NNIS = 3	0	0		
OR day drainage (mean ± S.D.)	483 ± 331	437 ± 290	1.0 (0.99–1.01)	
OR time (> 2 h)	25 (76%)	49 (77%)	0.96 (0.36–2.56)	
Post-operative factors				
Anticoagulation	24 (73%)	52 (81%)	0.62 (0.23–1.66)	0.48 (0.10– 2.20)
Hematoma	19 (58%)	4 (6%)	20.35 (5.98–69.30)***	11.78 (3.02–46.03)***
Days of drainage (mean ± S.D.)	6.5 ± 5.1	2.5 ± 2.2	1.41 (1.20–1.67)***	1.32 (1.08–1.62)**
Other sites of infection	7 (21%)	3 (5%)	5.47 (1.32–22.84)*	2.41 (0.33–14.78)
Transfusion	11 (33%)	14 (22%)	1.79 (0.70–4.55)	1.43 (0.40–5.11)

OR = odds ratio; CI = confidence interval; ASA = American society of anesthesiologists pre-operative assessment score; NNIS = national nosocomial infections surveillance.

*** $p < 0.001$;
** $p < 0.01$;
* $p < 0.05$.

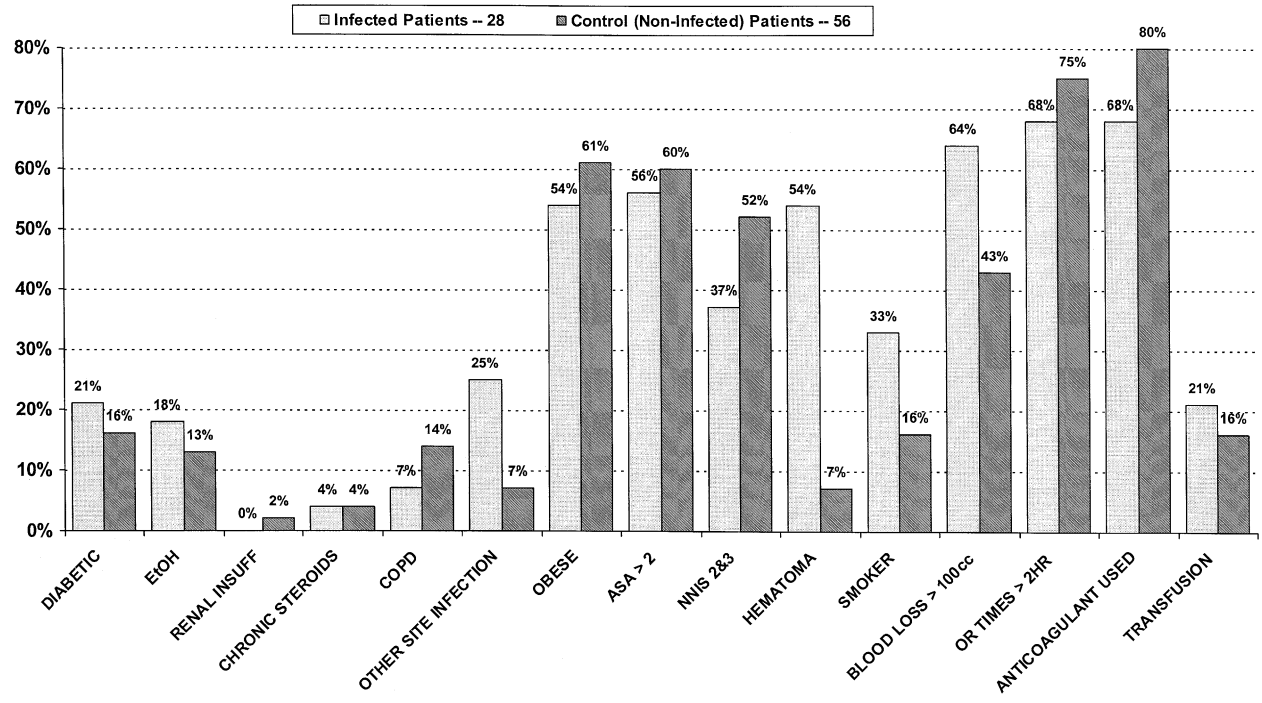

Fig. 1. Comparison of factors TKA and controls.

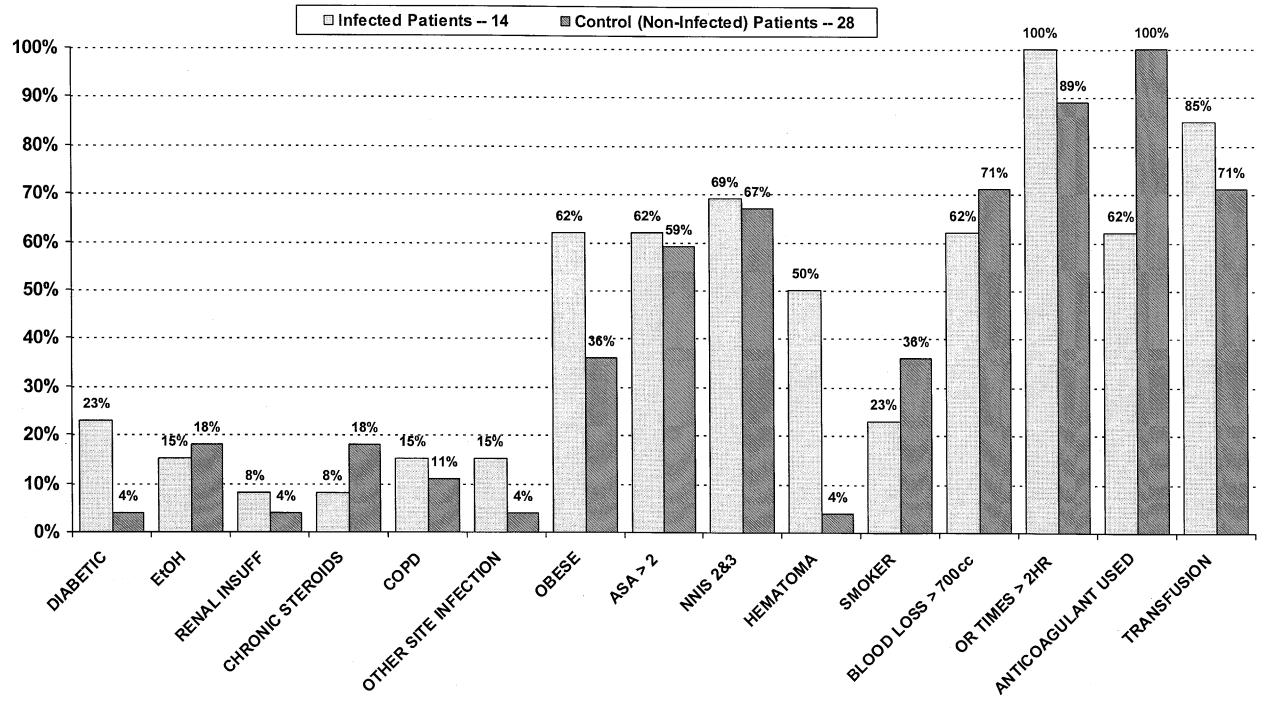

Fig. 2. Comparison of factors infected THA and controls.

64 controls, 61 (95%) subjects received Cephazolin, one (2%) Cefadyl, and two (3%) Vancomycin. There was no significant difference in all registered pre-operative parameters of both groups prior to the procedure.

SSSI

Thirty-three subjects (25 TKA and eight THA) developed SSSI at a mean of 20.3 + 6.6 days after surgery.

The overall 30-day infection rate was 2.1% for TKA and 0.7% for THA. Positive cultures were found in 94% (31/33) of the cases: six were obtained from swabs, seven from synovial samples, and 18 from tissue. Microbiology studies of the cultures revealed that 70% (23/33) of the cases had pure cultures (one organism grown), whereas 24% (8/33) had mixed cultures (more than one organism identified). There were 35 gram-positive organisms (83%) and seven gram-negative organisms (17%) identified (Figs. 3 and 4). Of the 33 SSSI, 26 (79%)

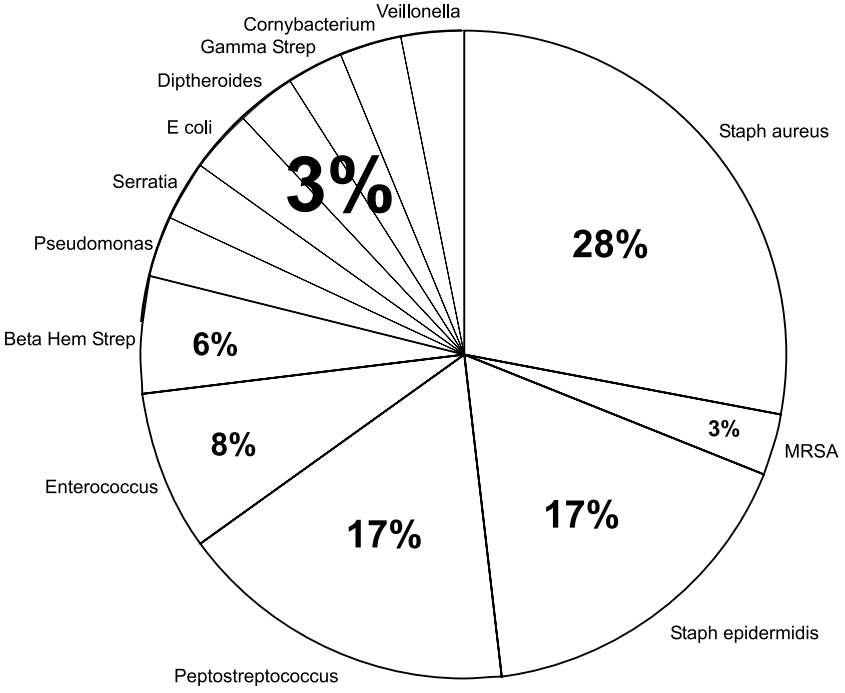

Fig. 3. TKA with SSSI wound cultures.

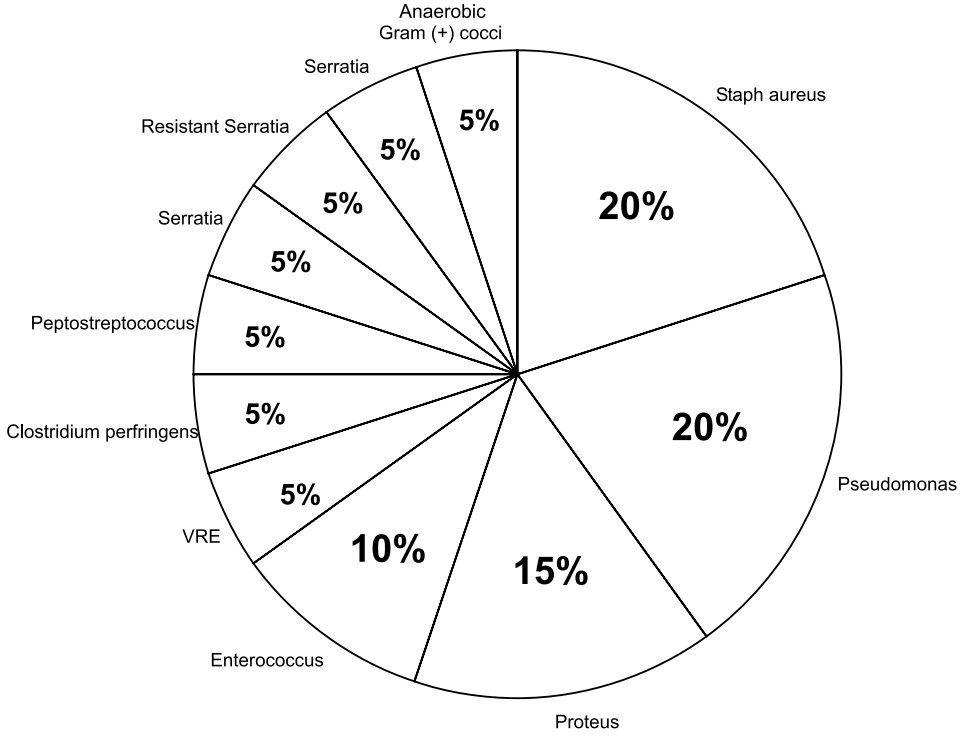

Fig. 4. THA with SSSI wound cultures.

required incision and drainage in the operating room, four (12%) were treated with intravenous antibiotics only, three (9%) required oral antibiotics.

DWI

Nineteen cases of DWI were registered in the study group: seven of them were diagnosed within 30 days after the procedure. Nine cases were *accumulated* at the end of the second month. Sixteen cases were accumulated at the end of the sixth month. The remaining three cases were observed during a later period (from the sixth to the 18-month following the procedure). No DWI cases were observed in the control group.

Out of the 19 DWI, twelve (63%) cases underwent surgical debridement and resection arthroplasty and inter-positional antimicrobial beads or blocks. Of the twelve resection arthroplasties, six patients (50%) subsequently underwent reimplantation. Seven subjects (36%) were treated with incision and drainage in the operating room and IV antibiotics post-operatively (for four to six weeks).

The difference in probabilities of developing DWI between the study and control groups was highly significant at the end of the 30-day period (seven out of 33 versus zero out of 64, $p = 0.0003$, Fisher exact test) and continued to grow during the subsequent observation periods ($p < 0.0001$).

Fifteen cases of deep infection were found among 25 TKA patients (60%) and four among eight (50%) THA patients, ($p = 0.7$ Fisher exact test).

Resource consumption

The case subjects consumed more health care resources than the controls at every stage of the medical process. The infected THA cases averaged 21.6 ± 10.1 days, and the TKA cases averaged 65.6 ± 58.8 days more in the hospital than the non-infected (control) subjects ($p < 0.01$). The THA cases required on average 1.6 ± 0.79 operations and 0.9 ± 0.64 readmissions more than the controls ($p < 0.01$). The TKA cases required on average 3.5 ± 2.3 operations and 1.8 ± 1.4 readmissions more than the controls ($p < 0.001$).

Predicting SSSI

Multivariate logistic regressions were calculated for each group of risk factors (pre-operative, intra-operative, and post-operative) in an attempt to predict SSSI (see Table 2). Univariate logistic regressions for individual predictor variables, uncorrected for multiple comparisons, are also included for descriptive purposes in Table 2. None of the pre-operative and intra-operative risk factors were significant. In the post-operative predictive model, two risk factors were statistically significant predictors of infection: hematoma (odds ratio = 11.8, $p < 0.001$) and days of post-operative drainage (odds ratio = 1.32, $p < 0.01$).

The number of post-operative drainage days (Fig. 5) was significantly different between non-infected (median = 2.0 days) and infected (median = 5.5 days) cases with $p < 0.0001$ (Mann–Whitney test). When the sample was split based on post-operative drainage days, subjects that had five days of drainage or greater were 12.7 times more likely to become infected than patients with less drainage time. Sensitivity and specificity curves were plotted against days of drainage in Fig. 6 and the receiver operator curve (sensitivity versus 1-specificity) is shown in Fig. 7.

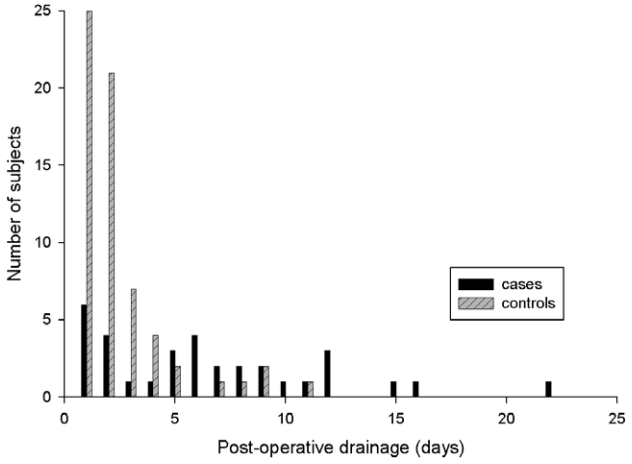

Fig. 5. Distribution of post-operative days of drainage of cases and controls following arthroplasty surgery.

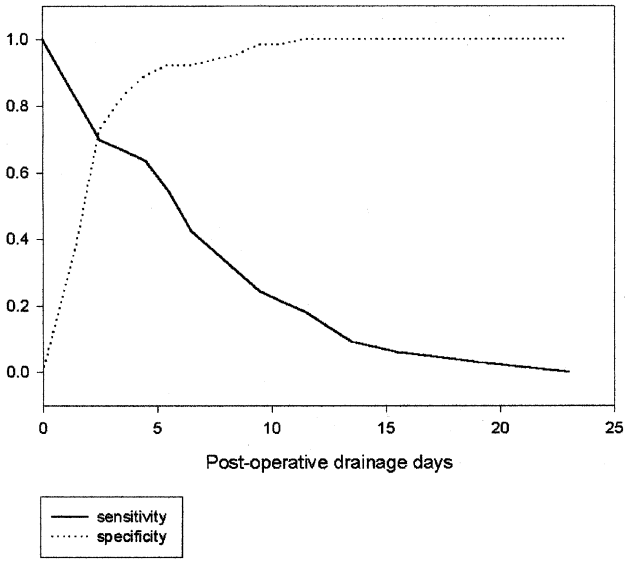

Fig. 6. Sensitivity and specificity curves plotted against post-operative days of drainage.

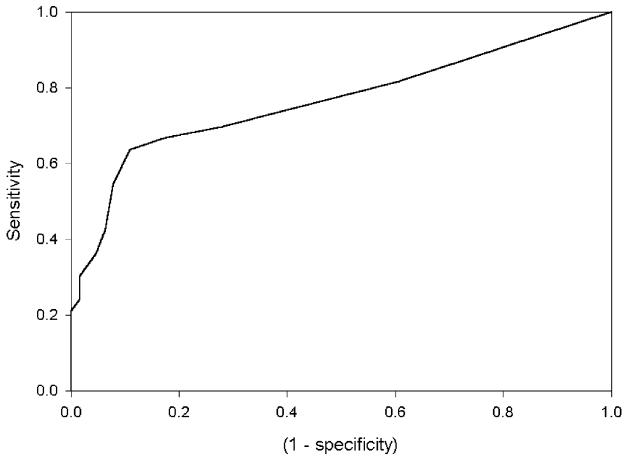

Fig. 7. Receiver operator curve-sensitivity versus 1-specifity.

Discussion

There are many patient factors that have been suspected as risks for DWI in arthroplasty patients. These factors are either manageable or non-manageable. All of them can be utilized in predicting the individual risk of developing DWI. Non-manageable factors (i.e., age, gender) do not lend themselves to medical interventions, unlike manageable factors. Among the potentially manageable factors, SSSI is of special importance due to the extremely high association with DWI and the potential existence of a causal relationship between them. It means that there is a high probability of managing the risk of developing DWI by preventing the development of SSSI (if the latter is feasible). To answer this question, it was necessary to test two basic hypotheses: (1) SSSI is potentially manageable and (2) there is high association between the incidents of DWI and SSSI.

The sampling procedures utilized in this study were selected primarily to evaluate factors that predict 30-day SSSI. Among the many factors that were tested, two were found to be significant: days of drainage and hematoma. Patients that developed hematoma and patients with prolonged duration of drainage were more likely to develop SSSI.

There is no proof that this strong correlation reflects a causal relationship or a more aggressive post-operative approach may modify the risk of SSSI. Surgical Site infection not involving the prosthesis has been independently shown as a risk factor for the development of DWI [28,36]. There are two models that can explain the high association between surgical site infection (SSSI) and DWI found in this study: "common factor" and causal. The common-factor model assumes that SSSI and DWI share a common factor (i.e., immuno-suppression that increases the predilection to acquiring infection), but preventing SSSI does not impact the probability of developing DWI. In contrary, the causal model is based on the assumption that preventing SSSI lowers the probability of developing DWI. SSSI perhaps creates a source of residual infection that is dormant and can trigger DWI at any point in time. For example, it has been documented that bacteria can persist in vitro (even on the surface of antibiotic-impregnated cement) as a result of a protective slime layer called the glycocalyx, which impairs antibiotic access and host defense mechanisms [19]. The available literature does not indicate which model is correct.

We do not know what is the best cutoff day for post-operative drainage that should trigger additional medical care such as surgical debridement and antibiotic use. According to our results more than five days of drainage significantly increases the risk of SSSI. We, therefore, have adopted this policy at our institution in a conservative fashion, and subjects with hematoma or persistent drainage in excess of seven days receive intravenous antibiotics and surgical debridement of the wound.

To answer the second question, a prospective case-control analysis was applied which included all the subjects with SSSI and a balanced control group without SSSI. The results showed highly significant differences between rates of DWI in the control group and the study group ($p < 0.0001$). These results indicate high stability of the association between SSSI and DWI.

The limitations of the control group with respect to the second question are: (1) small sample size, and (2) inclusion criteria. The control group was selected to match the study group that developed 30-day SSSI. Although this is a cost-effective way of comparing two groups over a long observation period, it requires caution when extrapolating these results to the entire arthroplasty population. Nevertheless, in our case the control group represents an almost random subset of patients without SSSI: matching included gender (all patients were male), type of procedure (TKA versus THA) and period (time the procedure was performed).

In a separate study we assessed the follow-up rate of this surveillance program and prospectively followed all TKA procedures since 1994. Of the 523 subjects: 494 (94.5%) returned for the scheduled 30-day appointment, 25 returned for the three month post-operative appointment (4.7%), and the remaining four (0.8%) returned for follow-up between the four and six month post-operative period.

Another important limitation is related to the low power of the study with respect to the incidence of DWI in the general population. The lack of documented cases of DWI in the control subjects does not signify the absence of DWI in the entire sample of patients that did not develop SSSI in the first 30-day post-operative period. Therefore, assuming that the rate of deep infection in the general population of 2305 patients is equal to approximately 2% we could expect to observe a total of 46 cases of DWI. Nineteen of them were observed in the

study group of 33 subjects. It leaves us with an estimated 27 cases of DWI (that were not observed) among patients with no SSSI during 30-day post-operative period and provides us with an estimated odds ratio of 110, which is even higher than that reported in the literature. The estimated odds ratio confirms a strong association between the incidence of SSSI and deep infection even in the general population.

Future efforts will be directed toward assessing the effectiveness of the proposed medical and surgical protocol with respect to preventing SSSI. A randomized clinical trail will be helpful in assessing the treatment of post-operative drainage at various post-operative intervals using different regimens, i.e., intravenous antibiotics versus intravenous antibiotics plus surgery.

Nineteen out of the 33 subjects that developed SSSI developed DWI, confirming the hypothesis that SSSI is a significant risk factor for predicting DWI. Future research should focus on addressing SSSI in hopes decreasing the rate of DWI. Our study shows that drainage days and hematoma are significant risk factors for SSSI.

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